ECS Concentration at UCSD

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Patrick Mercier, Gabriel M. Rebeiz

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UC San Diego
JACOBS SCHOOL OF ENGINEERING

Overview of Talk

- *What is ECS?*
- *Where will I work?*
- *What courses to take?*
- *Should I do an MS and a PhD?*
- *Professors and their research areas*

What is ECS?

- *Electronic Circuits and Systems*
  - *Analog circuits (amplifiers, mixers, oscillators, low-power/medical, etc.)*
  - *Mixed-signal circuits (ADCs, DACs, PLL, etc.), PMIC (power management)*
  - *RF circuits for communications, radars, sensors (amplifiers, mixers, power amplifiers, etc. at high frequencies - RF/Microwave/Mm-wave)*
  - *Digital and digital-like circuits (high-speed wireline circuits, VLSI, high speed processors, image processors, etc.)*
  - *Includes lots of high-frequency PCB layout techniques too*

- *Basically, all the chips and systems (RF systems, communication systems, cell phones, base-stations, wireline systems, optical networks, biomedical systems, etc.) which use these chips.*

Where are Circuits and Systems?

- *EVERYTHING THAT YOU HAVE OR USE OR DEPEND ON CONTAINS CIRCUITS, LOTS AND LOTS OF CIRCUITS!!! It is a >3Trillion industry in the US. It is ~10% of the US GDP. We are amazing at circuits!!*
  - *Phones, computers, pads, watches, game consoles, cameras, etc.*
  - *WLAN boxes, cable boxes, satellite TV*
  - *Base-stations, cable stations, internet backbone stations*
  - *Data centers (racks and racks of servers)*
  - *Cars (!!) – they contain more than 80 micro-controllers today*
  - *Bio-medical equipment*
  - *Communication, radar, sensor equipment (commercial and defense)*
  - ***Everything that you touch today contains lots of circuits!!***

Where will I work?

- *Electronic Circuits and Systems students are highly paid. One of the highest in EE/ECE (source IEEE)*
- *The US is the #1 country in ECS in the world!!! We design most of the circuits in the entire world. Companies include:*
  - *Qualcomm, Intel, Broadcom/Avago, Texas Instruments, Apple, Google, Samsung LSI, MTK, Huawei/Future-Wei, Hi-Silicon, Nokia*
  - *Analog Devices, Freescale/NXP, Silicon Labs, Qorvo, Skyworks, IDT, Cypress, Maxlinear, MicroChip, Infineon, ST-Micro, Keysight, National Instruments, etc.*
  - *Intel, AMD, Marvell, Xylinx, Micron, Cadence (VLSI)*
  - *Inphi, Infinera, Ciena, Broadcom, etc. (optical wireline)*
- *Raytheon, NG, Lockheed Martin, Boeing, Qorvo (defense), etc.*

ECS at UCSD

- **Electronic Circuits and Systems (sixty-eight units)**
  - Breadth Courses: ECE 100, 101, 102, 103, 107, 109
  - Depth Courses: ECE 164, 165, 166
  - Technical Electives: five upper-division engineering, math, or physics courses
  - Professional Electives: two upper-division courses
  - Design Course: one of ECE 111, 115, 140B, 190, or 191

- **ECE 164: Analog Circuit Design**
- **ECE 165: Digital (VLSI) Design**
- **ECE 166: RF/microwave Circuits Design**

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- **Electives: We recommend that students take (at the undergrad level):**
  - **DSP, Random Processes, Digital Comms, Antennas (ECE123), ECE163.**
- **Electives: We recommend that students take (at the undergrad/grad level):**
  - **ECE260ABC, ECE264ABC, ECE265ABC, ECE222ABC (few of them if interested)**
  - **Only if you are really interested – otherwise, take DSP, Random Processes, etc..**

Should I do an MS?

- **ABSOLUTELY YES!!!!**
- MS results in substantial additional knowledge
- You will know much more, you will be paid much more!! ☺
- BS students in circuits end up being test engineers or product support engineers. MS and PhD students end up being the advanced design engineers.

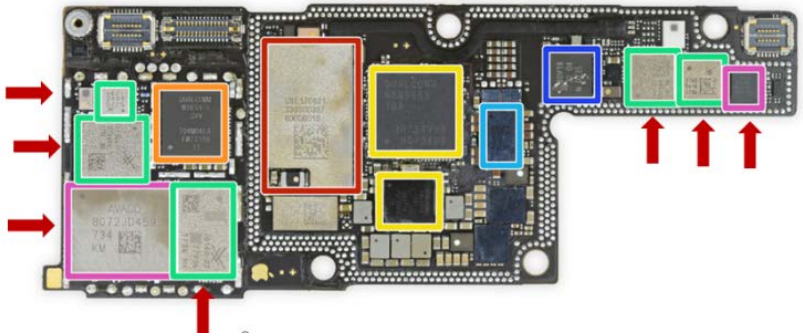
- **We recommend that students take (at the grad level):**
  - **ECE 260ABC Advanced VLSI**
  - **ECE 264ABC Advanced Analog and Mixed-Signal Design (ADCs, DACs, PLLs)**
  - **ECE 265ABC Advanced RF Systems, RFIC, Power Amplifier Design**
  - **Do not forget Antennas, DSP, Random Processes, Digital Comm., Bio-Medical/Low Power, Power Systems, Robotics, etc. (there is lots and lots to learn at UCSD!!).**
  - **Take a Software or Machine learning course too. You never know when you will need it. This is your time to learn!!**

Should I do a PhD?

- It depends on your goals in life ☺
- You will work for 3-4 years getting deep and deep into an area
- It is exciting but it is hard work too!!
- It can lead to a life in R&D, or a life in industry too (lots of companies hire PhDs for advanced design)
- The only path to become a professor, or to be in a high-level position in R&D in industry or government
- Find an area that you like, find an advisor that you like, do some good work, publish a couple of good papers, and voila – you have a PhD!

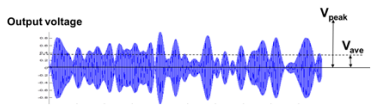
Professor: Peter Asbeck

Power Amplifiers for Wireless Communications

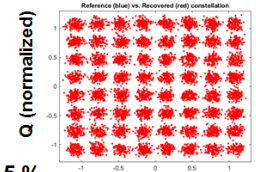


High Power Efficiency
High Bandwidth
High Accuracy

Low Error Vector Magnitude (EVM)
Low Adjacent Channel Power Ratio (ACPR)

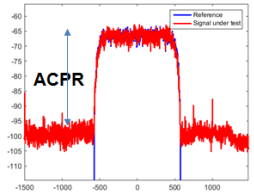


Signal constellation at baseband



EVM = 5.5 %
(-25.2 dB)

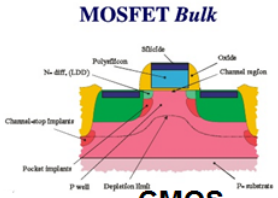
Signal spectrum



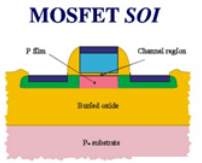
ACPR =
-34 dBc

How to Get What is Needed

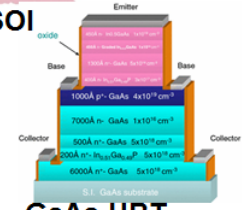
GaAs pHEMT



CMOS

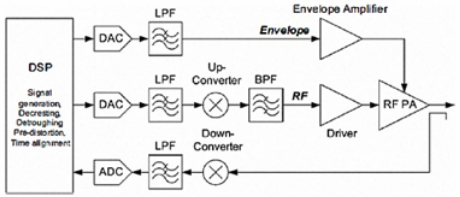


CMOS-SOI

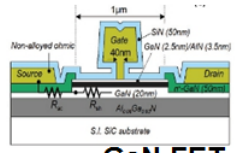


GaAs HBT

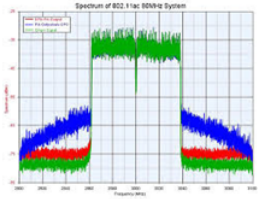
The best semiconductor technology
The cleverest circuits
The best algorithms for digital correction



Envelope tracking



GaN FET

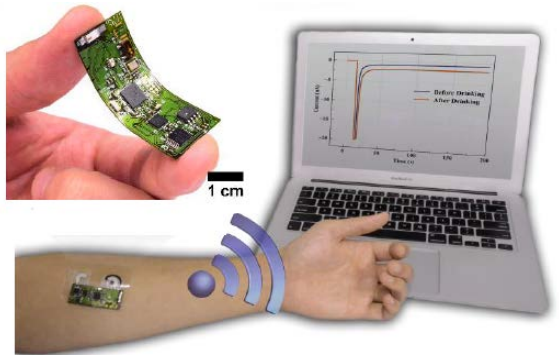


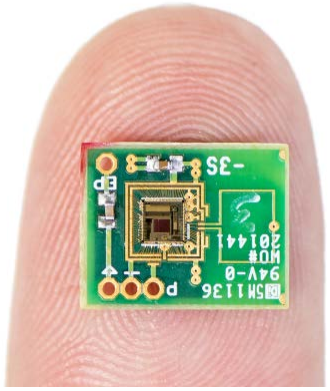
Digital predistortion

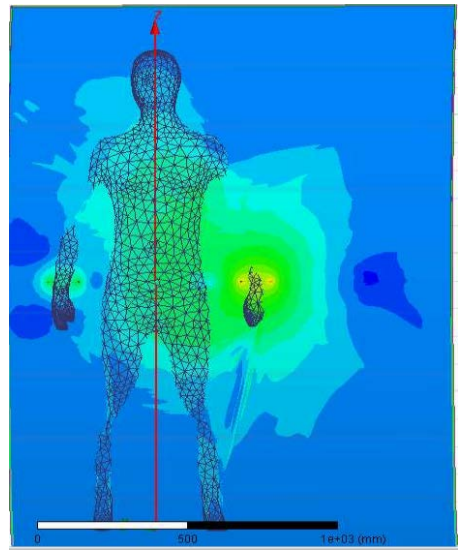
Professors: Drew Hall and Patrick Mercier

Prof. Patrick Mercier:

- Director, Energy-Efficient Microsystems Lab
- Co-Director, Center for Wearable Sensors







Research focus:

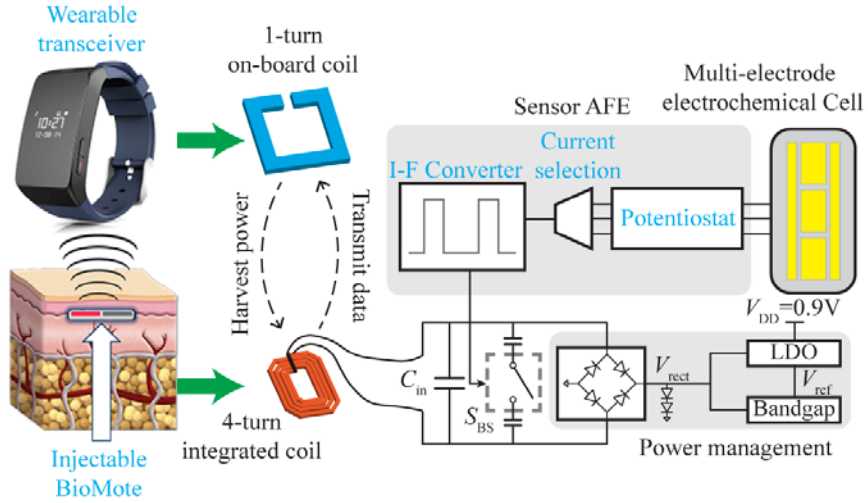
Wearable sensors and bio-energy harvesting

Sub-nanowatt wireless sensing systems

Wireless body-area networks

Prof. Drew Hall - Injectable "BioMotes" for Continuous Health Monitoring

- **Objective:** Design a wireless injectable biosensor (a "BioMote") for continuous, long-term substance abuse monitoring
- **Highlight:** First-reported sub-1 µW fully-integrated, injectable biosensor reported in the literature

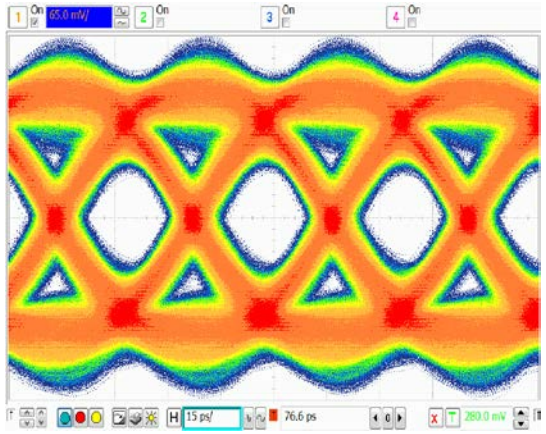


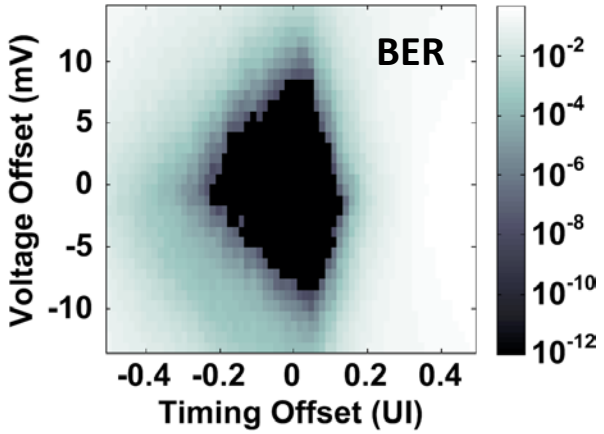
Professors: Ian Galton and Tzu-Chien Hsueh

Tzu-Chien Hsueh
Assistant Professor
Integrated Communication Circuits Lab
ECE, UC San Diego

Analog & Mixed-Signal ICs for

- Wireline Communication Systems
- Data Centers & Ethernet
- Electrical-to-Optical Interfaces
- SerDes Links & Broadband Transceivers
- Silicon Photonics





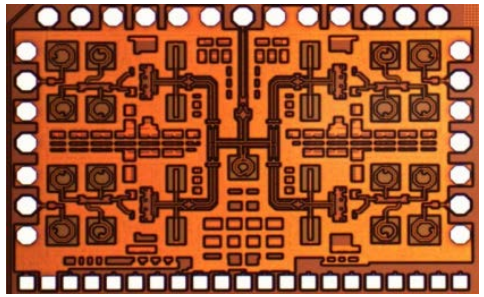
Prof. Ian Galton

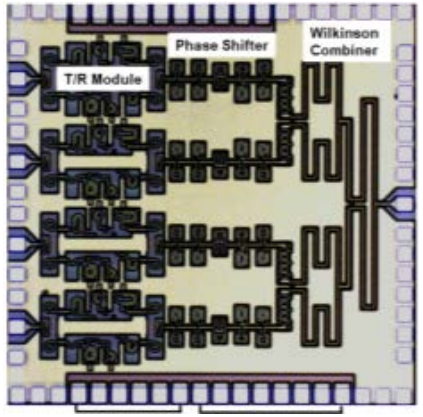
Research Emphasis: Digital calibration and digital-like analog circuits that solve present-day IC limitations. Design ICs with record-setting performance

Example Prior Results:

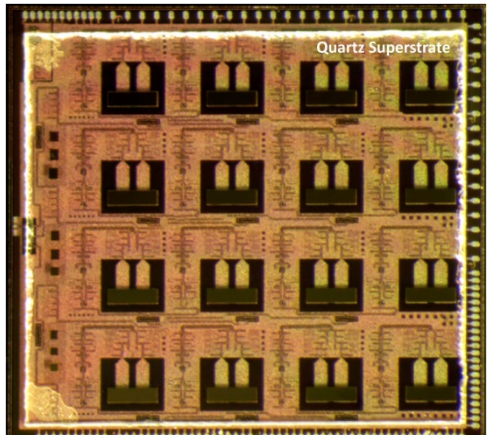
- Tree-structured dynamic element matching–Used in most mobile phones, many audio CODECs, many TV tuners and cable boxes, and many automotive radar processors
- Adaptive digital gain, mismatch, and nonlinearity calibration techniques–Used in most high-resolution pipelined ADCs
- FDC-based digital PLLs–Used in Snapdragon processor-based phones and soon to be used in high-performance ADI PLL product
- Digitally calibrated VCO-based ADCs with calibration–Soon to be used in multiple radio IC products

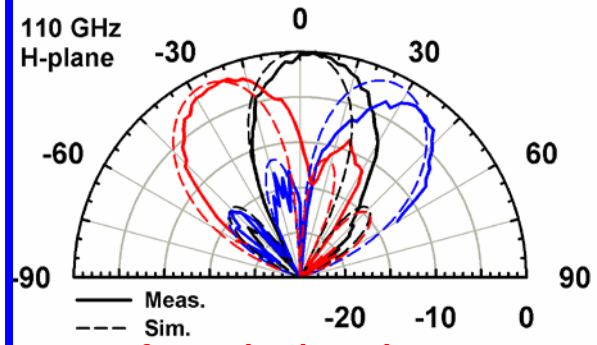
Professor: Gabriel Rebeiz



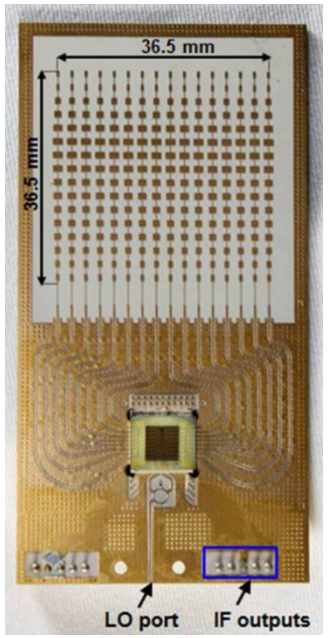


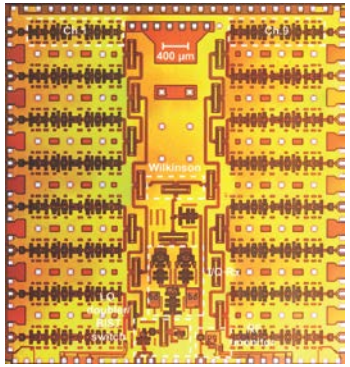
24 GHz CMOS Rx phased array
35 GHz SiGe Tx-Rx phased array



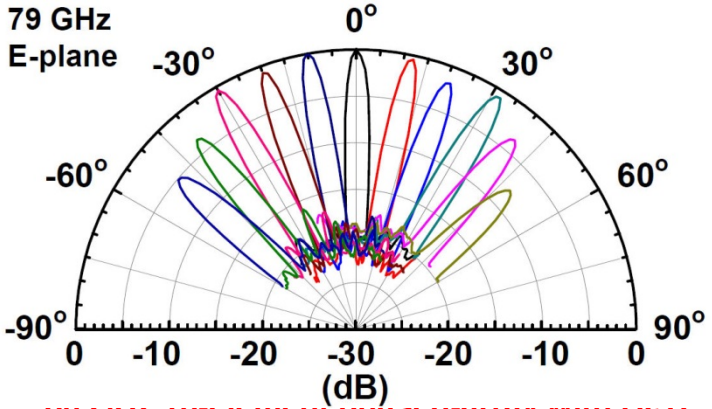


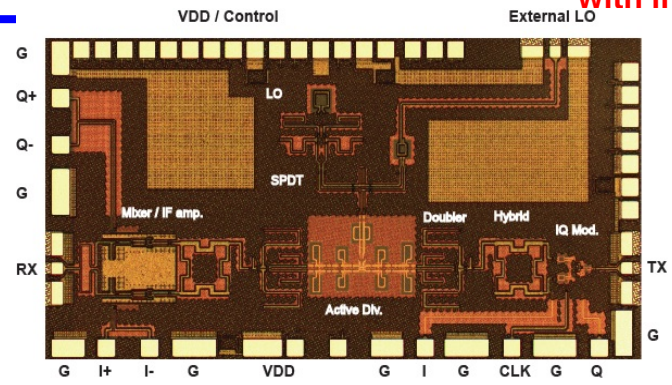
Wafer-scale phased arrays with integrated antennas

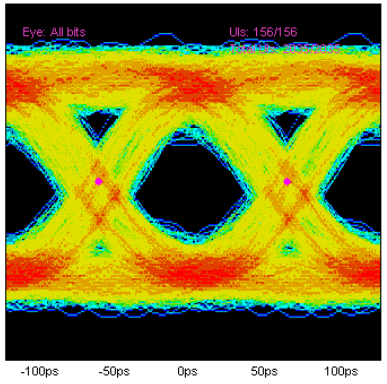




Automotive phased array radars for autonomous vehicles







150 GHz CMOS T/Rx with 20 Gbps

(R&D100 Award, Microwave Prize).